Rules for the Semantic Web

The WSML Approach

Jos de Bruijn
jos.debruijn@deri.org

Digital Enterprise Research Institute (DERI)
National University of Ireland, Galway
University of Innsbruck, Austria

April 27, 2005
Web Rule Language in its Context

- FOL ++
- Rules
- OWL
- RDF(S)
- XML
- Unicode
- URI
Outline

The Web Service Modeling Language WSML
  WSML Language Variants
  WSML Syntax
  WSML Logical Expressions
  WSML Exchange Syntaxes

Key Features of WSML

Layering on the Semantic Web

Conclusions
Outline

The Web Service Modeling Language WSML
- WSML Language Variants
- WSML Syntax
- WSML Logical Expressions
- WSML Exchange Syntaxes

Key Features of WSML

Layering on the Semantic Web

Conclusions
The Web Service Modeling Language WSML

- A language for the Semantic description of Web Services
- Based on the Web Service Modeling Ontology WSMO
  - Ontologies
  - Web Services
  - Goals
  - Mediators
- Disregard Web Service-related aspects in this presentation
- Semantics based on well-known logical language paradigms:
  - Description Logics
  - Logic Programming
  - Frame Logic
- WSML distinguishes between:
  - Conceptual modeling
  - Logical expressions
WSML Language Variants

- WSML-Core
- WSML-Rule
- WSML-Full
- WSML-DL

First-Order Logic
(with nonmonotonic extensions)

Description Logics

Logic Programming
(with nonmonotonic negation)
Prologue
By Example

// Specification of the WSML variant
wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-flight"

// Namespace prefix declaration
namespace {_"http://www.example.org/example#",
    dc _"http://purl.org/dc/elements/1.1/"
}

// WSML specifications
ontology _"http://www.example.org/exampleOntology"
    [...]  
goal _"http://www.example.org/exampleGoal"
    [...]  

etc...
WSML Specification

A WSML specification has the following structure:

- Type of specification (Ontology/Web Service/Goal/Mediator)
- Header
  - Non-Functional Properties
  - Imported Ontologies
  - Used Mediators
- Content of the specification
Ontologies

Header

[.. prologue ..]

ontology "http://www.example.org/ontologies/example"

nonFunctionalProperties
dc#title hasValue "WSML example ontology"
endNonFunctionalProperties

importsOntology {

}

usesMediator {

}
Ontologies
Concepts

- Form the basic terminology of the domain of discourse
- May be organized in a hierarchy (using `subConceptOf`)
- Has a number of attributes:
  - Attributes have a type:
    - Type constraint (`ofType`)
    - Type inference (`impliesType`)
  - Attributes may have cardinality constraints
  - Attributes may have a number of features:
    - Transitive
    - Symmetric
    - Reflexive
    - Inverse of another attribute
Ontologies

Concepts - example

```xml
concept Person subConceptOf { Primate, LegalAgent }

nfp
// Related axiom
dc#relation hasValue personUncle

endnfp
// A functional attribute (maximal cardinality=1)
hasName ofType (0 1) string
// hasParent is the inverse of hasChild
hasChild inverseOf(hasParent) ofType Person
hasParent ofType Person
hasBrother ofType Person
```
Ontologies

Relations

- Inspired by relations in mathematics
- Have arbitrary arity
- May have typing associated with its arguments
- May be organized in a hierarchy (using `subRelationOf`)

relation Marriage (ofType Person, ofType Person, ofType _date)

```nfp
dc#description hasValue "Marriage is a relation between two persons, which are the participants in the marriage, and the date in the marriage."
endnfp```
Ontologies

Instances

- Are the objects in the domain
- May be member of one or more concepts
- May have a number of attribute values associated with it

```
instance johnmemberOf Person
nfp
dc#description hasValue "The person John Smith"
endnfp
hasName hasValue "John Smith"
```
Ontologies
Relation Instances

- Are tuples in a relation

relationInstance Marriage(john,mary, date(2005,03,03))
nfp
dc#description hasValue "John and Mary married on 2005-03-03."
endnfp
Ontologies

Axioms

▶ Refine concept and relation definitions in Ontologies using logical expressions
▶ Add arbitrary knowledge and constraints
▶ Entry point for logical expressions, rules in ontology
▶ Allowed logical expressions depend on WSML variant

axiom personUncle

nfp
dc#description hasValue "The brother of a person’s parent is that person’s uncle."

endnfp
definedBy

?x[hasUncle hasValue ?z] impliedBy ?x[hasParent hasValue ?y] and ?y[hasBrother hasValue ?z].
Logical Expression syntax

- Used for refining Ontologies and specifying Web Service functionality
- Allow to use the full expressive power of the underlying logic
- Frame syntax (F-Logic)
- Logic Programming constructs
  - Negation-as-failure
  - LP implication
- Variables are implicitly universally quantified outside the formula
- Symbols resemble natural language and are unambiguous
- WSML variants restrict allowed logical expressions
Examples

// a simple rule: the brother of someone's parent is that person's uncle
?x[hasUncle hasValue ?z] : ¬ ?x[hasParent hasValue ?y] and ?y[hasBrother hasValue ?z].

// the same person cannot be both a man and a woman (constraint)

// every person has a father
?xmemberOf Person implies exists ?y (?x[father hasValue ?y]).
Examples

// a simple rule; the brother of someone’s parent is that person’s uncle

// ?x[hasUncle hasValue ?z] :- ?x[hasParent hasValue ?y] and
?y[hasBrother hasValue ?z].
Examples

// a simple rule; the brother of someone’s parent is that person’s uncle
?x[hasUncle hasValue ?z] :- ?x[hasParent hasValue ?y] and
  ?y[hasBrother hasValue ?z].

// the same person cannot be both a man and a woman (constraint)
!- ?x memberOf Man and ?x memberOf Woman.
Examples

// a simple rule; the brother of someone's parent is that person's uncle
?x[hasUncle hasValue ?z] :- ?x[hasParent hasValue ?y] and
   ?y[hasBrother hasValue ?z].

// the same person cannot be both a man and a woman (constraint)
!- ?x memberOf Man and ?x memberOf Woman.

// every person has a father
?x memberOf Person implies exists ?y (?x[father hasValue ?y]).
WSML XML Syntax

- Syntax for exchange over the Web
- Translation between human-readable and XML syntax
- XML Schema for WSML has been defined
WSML XML
Example

<!ENTITY ex "http://www.example.org/ontologies/example#" >
<!ENTITY wsml "http://www.wsmo.org/wsml/wsml−syntax#" >
<wsml xmlns="&wsml;"
variant ="http://www.wsmo.org/wsml/wsml−syntax/wsml−flight” >
  <importsOntology>
    http://www.wsmo.org/ontologies/location
  </importsOntology>
  <concept name="&ex;Person” >
    <nonFunctionalProperties>[..]</nonFunctionalProperties>
    <attribute name="&ex;hasName” type="constraining” >
      <range>&wsml:string</range>
      <maxCardinality>1</maxCardinality>
    </attribute>
      [..]
  </concept>
  [..]
</wsml>
WSML RDF Syntax

- Interoperability with RDF applications
- Maximal reuse of RDF and RDFS vocabulary
- WSML RDF includes most of RDF
- Translation between human-readable and RDF syntax
- For logical expressions, XML literals are used
WSML RDF

Example

```xml
<http://www.example.org/ontology> rdf#type wsml#ontology
<http://www.example.org/ontology> wsml#variant
  <http://www.wsmo.org/wsml/wsml−syntax/wsml−flight>
<http://www.example.org/ontology> wsml#nfp _:nfp1
_:nfp1 dc#title "WSML example ontology"^^xsd#string
<http://www.example.org/ontology> wsml#importsOntology
  <http://www.wsmo.org/ontologies/location>
<http://www.example.org/ontology> wsml#hasConcept ex#Person
ex#Person wsml#hasAttribute _:att1
_:att1 wsml#attribute ex#hasName
_:att1 wsml#ofType xsd#string
_:att1 wsml#maxCardinality "1"^^xsd:integer
<http://www.example.org/ontology> wsml#hasAxiom
  ex#personUncle
ex#personUncle rdfs#isDefinedBy
  "<impliedByLP>..</impliedByLP>"^^rdf#XMLLiteral
```
Outline

The Web Service Modeling Language WSML
  WSML Language Variants
  WSML Syntax
  WSML Logical Expressions
  WSML Exchange Syntaxes

Key Features of WSML

Layering on the Semantic Web

Conclusions
Key Features of WSML

- One framework for a set of Layered Languages
- Normative, Human-readable Syntax
- Separation of conceptual modeling and logical expressions
- Semantics based on well-known formalisms
- Relation between DL and Rules through common subset
- Web Language
- Frame-based syntax
Outline

The Web Service Modeling Language WSML
   WSML Language Variants
   WSML Syntax
   WSML Logical Expressions
   WSML Exchange Syntaxes

Key Features of WSML

Layering on the Semantic Web

Conclusions
The WSML Approach to language layering

FOL++

DL    Rules

Core
Current Languages on the Semantic Web

- OWL
- RDF(S)
- XML
- Unicode
- URI
Current Languages on the Semantic Web

- OWL
- RDF(S)
- XML
- Unicode
- URI

How to Incorporate rules?

- Layering Rules on top of OWL (e.g. SWRL)
- Hybrid approach (e.g. CARIN/AL-Log)
- Using a common subset for interoperation (e.g. DLP)
Common subset

- FOL ++
- Rules
- OWL
- RDF(S)
- XML
- Unicode
- URI
Common subset

- Maintain nice properties of each of the underlying logics
- Reuse existing implementations of rules and description logic
- Allow straightforward extension in both directions
Outline

The Web Service Modeling Language WSML
  WSML Language Variants
  WSML Syntax
  WSML Logical Expressions
  WSML Exchange Syntaxes

Key Features of WSML

Layering on the Semantic Web

Conclusions
Conclusions

WSML position on a Rules language for the Web:
Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language
Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language
3. Ontology meta-model independent from underlying logic
Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language
3. Ontology meta-model independent from underlying logic
4. Separation of conceptual modeling and logical expressions
5. Normative, Human-readable Syntax
Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language
3. Ontology meta-model independent from underlying logic
4. Separation of conceptual modeling and logical expressions
5. Normative, Human-readable Syntax
6. Semantics based on well-known formalisms; allows integration with existing systems
Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language
3. Ontology meta-model independent from underlying logic
4. Separation of conceptual modeling and logical expressions
5. Normative, Human-readable Syntax
6. Semantics based on well-known formalisms; allows integration with existing systems
7. Web Language
Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language
3. Ontology meta-model independent from underlying logic
4. Separation of conceptual modeling and logical expressions
5. Normative, Human-readable Syntax
6. Semantics based on well-known formalisms; allows integration with existing systems
7. Web Language
8. Frame-based syntax
Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language
3. Ontology meta-model independent from underlying logic
4. Separation of conceptual modeling and logical expressions
5. Normative, Human-readable Syntax
6. Semantics based on well-known formalisms; allows integration with existing systems
7. Web Language
8. Frame-based syntax

WSML resources
http://www.wsmo.org/wsml/wsml-syntax#
Web Rule Language in its Context